Meteorological Changes Near Water Surface During Tropical Cyclones

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Abstract

This paper sought to explore and analyze the changes in the meteorological conditions of wind speed, water temperature, atmospheric temperature, and barometric pressure near the water surface when a tropical storm or hurricane is present. Data was gathered from the National Oceanic and Atmospheric Administration (NOAA) and cleaned to be used in an R program that generates regression models testing which model is most accurate. It was determined that the model containing the variables wind speed, barometric pressure, and water temperature had the lowest residual standard error and the highest multiple and adjusted R^2 values meaning that it was, all around, the best model for predicting whether or not a measurement was taken during a storm.

Keywords: meteorological conditions, changes during hurricanes, tropical cyclones

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Hurricanes and tropical storms, tropical cyclones that spawn in the North Atlantic and regions of the Pacific Ocean, are devastational forces of nature that generally spawn during a period of the year in which conditions are particularly favorable—though they are known to sometimes spawn outside of this time period. These weather phenomena adversely affect the State of Florida, which is where Florida Southern College is located, due to its peninsular shape and proximity to the places where they normally spawn, so there is a particular interest for individuals and institutions within the state to understand and predict them. As Malmstadt et al. of Florida State University state in their 2009 paper, "Florida has been visited by some of the most destructive and devastating hurricanes on record in the United States causing well over $450 billion in damage since the early 20th century," which was an average of roughly $4.13 billion in damage per year at the time the paper was published.

Methodology

Data

Source and Pre-Processing

Data about the storms and data from buoy 42036 were imported from the National Oceanic and Atmospheric Administration (NOAA) into a Google Sheets file where data outside the year 2005 was removed, missing data was censored or removed, and variables not explored in this paper were removed. Then a dummy variable was created for the storm data to represent whether the measurement was before (0) or after (1) the storm's max wind speed. A dummy variable was also created, during the creation and running of the R program, to mark whether a buoy measurement was during a storm (1) or not (0).

Descriptive Statistics and Exploratory Data Analysis

The cleaned hurricane data contains the variables: year, name, status, latitude, longitude, wind speed, pressure, timestamp, maximum sustained wind speed of the storm, and whether or not the measurement was taken after the max winds. It consists of 2,414 samples, making it tall in height, and 17 variables. The data was collected once per hour and is not complex since it came from a single source.

The cleaned buoy data contains the variables: year, month, day, hour, wind speed, barometric pressure, atmospheric temperature, water temperature, timestamp in days, and timestamp in hours. It consists of 8,346 samples, making it tall in height, and 10 variables. The data was collected once per hour and is not complex since it came from a single source.

Regression Modeling

Since this paper was only exploring the relation of four variables, meaning fifteen possible combinations, instead of performing forward or backward selection as one would usually see in this type of research, the R program written for this purpose simply modeled all fifteen possible models and the results were compared by a human.

Results

The models and their relevant information used to make a decision can be seen in the table just below with the best in each category being highlighted. For reference, WSPD is wind speed, BAR is barometric pressure, ATMP is air temperature, and WTMP is water temperature. Furthermore, lower residual standard error (RSE) values are better whereas higher multiple and adjusted R^2 values are better. Note that the model including all four variables is practically tied with the model including three variables except air temperature. It is worth noting that the latter model was determined to be better since it has a marginally better R^2 value and it was found that the coefficient for the air temperature variable had a t-value of -0.061 with a probability of 0.951 for > | t |, so it was deemed best to omit the variable.

Model	Residual Standard Error	Multiple R^2	Adjusted R^2
During ~ WSPD + BAR + ATMP + WTMP	0.3991	0.2446	0.2462
During ~ WSPD + BAR + WTMP	0.3991	0.2466	0.2463
During ~ WSPD + BAR + ATMP	0.4125	0.1948	0.1945
During ~ WSPD + ATMP + WTMP	0.404	0.228	0.2277
During ~ BAR + WTMP + ATMP	0.4106	0.2023	0.202
During ~ WTMP + ATMP	0.4125	0.1949	0.1947
During ~ BAR + WTMP	0.4115	0.1988	0.1986
During ~ BAR + ATMP	0.4268	0.1381	0.1379
During ~ WSPD + WTMP	0.4053	0.2229	0.2227
During ~ WSPD + ATMP	0.423	0.1532	0.153
During ~ WSPD + BAR	0.4578	0.008272	0.008032
During ~ WTMP	0.4153	0.1839	0.1838
During ~ ATMP	0.4325	0.1148	0.1147
During ~ BAR	0.4596	0.0004199	0.000299
During ~ WSPD	0.4578	0.008059	0.007939

Conclusion

In conclusion, per the analyses and modeling in this project, air temperature does not significantly change when a tropical cyclone is present whereas wind speed, water temperature, and barometric pressure do. These conclusions could be flawed, though, as the methods of determining whether or not a storm was present involved simply considering a storm to be present if there was one active at that time. More sophisticated analyses involving computations surrounding storm proximity to the buoy and bringing in data from many other buoys would give a better, more accurate picture of the change in these variables during the presence of a tropical cyclone.

References

Malmstadt, J., Scheitlin, K., & Elsner, J. (2009). *Florida Hurricanes and Damage Costs*. Orange County Water Atlas. http://orange.wateratlas.usf.edu/upload/documents/563_MalmstadtScheitlinElsner2009.pdf